MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2017/2018

EMF4096 – RADAR SYSTEM DESIGN AND ANALYSIS

(TE)

5 MARCH 2018
9:00 A.M- 11:00 A.M
(2 Hours)

INSTRUCTION TO STUDENT

1. This examination paper consists of 7 pages including cover page with 4 Questions only.

2. Attempt **ALL** the questions. Each question carry equal marks and distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided. Please number your answers clearly.

Question 1

(a) Briefly explain a radar range resolution. Draw a related diagram to support your answer.

[6 marks]

(b) A section of the transmitted and received waveforms from a typical pulsed radar is shown in Figure Q1. The duty cycle is given as 5%.

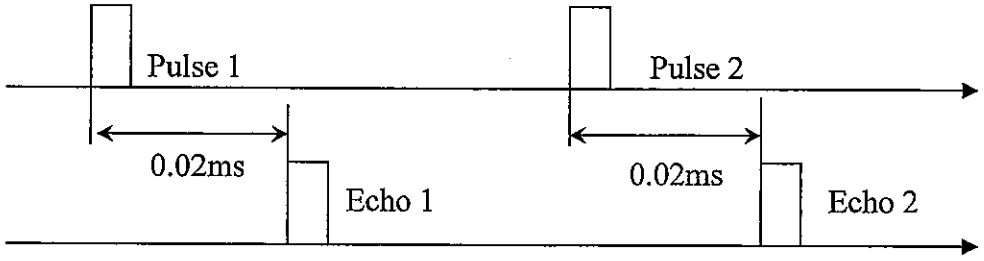


Figure Q1

Calculate the following:

(i) Range for the first echo.

[2 marks]

(ii) The average power, if the peak power is 10 kW.

[2 marks]

(iii) The Pulse Repetitive Frequency (PRF) if max unambiguous range is given as 7500 m.

[2 marks]

(iv) The range resolution.

[2 marks]

(v) Range if received echo is from previous pulse.

[2 marks]

(c) In a typical radar doppler, the transmitted signal is given as, $S(t) = \cos(2\pi f_o t)$ and the received signal after time two way time delay is given as, $S_r(t) = \cos(2\pi f_o t(t - \Gamma_d))$, where f_o is an operating frequency, t is a time in second and Γ_d is time delay. Derive an equation of the received signal as a function of received frequency, f_r and received phase, φ_r.

[6 marks]

(d) Provide TWO (2) applications of Continuous Wave radar (CWR).

[3 marks]

Continued...

Question 2

(a) In Figure Q2, the modulating frequency is 1.57 kHz, the bandwidth is 180 kHz and the center frequency is 2.4 GHz of Frequency Modulation Continuous Wave (FM-CW) radar with a linear FM modulation. The radar detects a target moving away from the radar, at a range of 40 km with a velocity of 120 m/s.

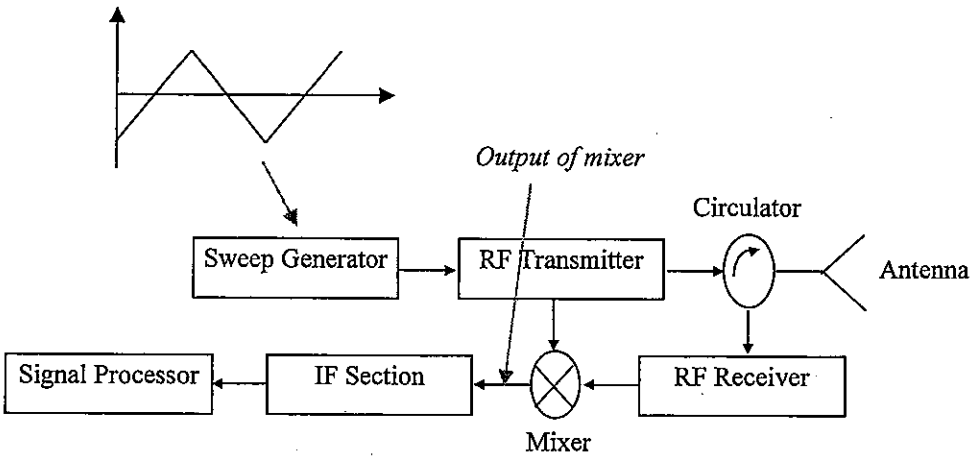


Figure Q2

(i) Analyze the above for doppler and determine the respective frequencies present at the output of the mixer.

[4 marks]

(ii) Design the return echo of the linear Frequency Modulation (FM) signal (frequency vs. time). On your drawing, show the relative position of the transmitted signal.

[3 marks]

(iii) If a sawtooth waveform is used instead of a triangular waveform for the modulation signal, determine the frequencies present at the output of the mixer. Given the modulating frequency of the sawtooth waveform is the same as the triangular waveform.

[3 marks]

Continued...

(b) In Pulse Repetitive Frequency (PRF) staggering radar, given the frequency, f = 1.2GHz, $PRF_1 = 667$, $PRF_2 = X$, $PRF_3 = Y$ and $PRF_4 = 841$ Hz with $n_1 = 29$, $n_2 = 27$, $n_3 = 25$ and $n_4 = 23$. Calculate:

(i) value of X and Y

[2 marks]

(ii) blind speeds

[3 marks]

(iii) first complete null blind speed.

[3 marks]

(c) Describe about Polarimetric Synthetic Aperture Radar (Pol-SAR).

[5 marks]

(d) In Ground Penetrating Radar (GPR), an electrode magnetic waves emitted into the ground and time measured for wave to be reflected and received. Determine the depth below the surface of an object that is detected at 46 ns in dry sand with relative permittivity, $\varepsilon_r = 4$.

[2 marks]

Continued...

Question 3

(a) Describe how Radar Cross Section (RCS) is dependency on the wavelength and aspect angle.

[8 marks]

(b) An X-band pulse radar has probability of detection $P_d = 0.95$, time of false alarm $T_{fa} = 8$ minute and operating bandwidth $B = 2$ MHz. The probability of detection versus single pulse Signal-to-Noise-Ratio (SNR) for several values of P_{fa} is shown in Figure Q3. Assume single pulse processing is used.

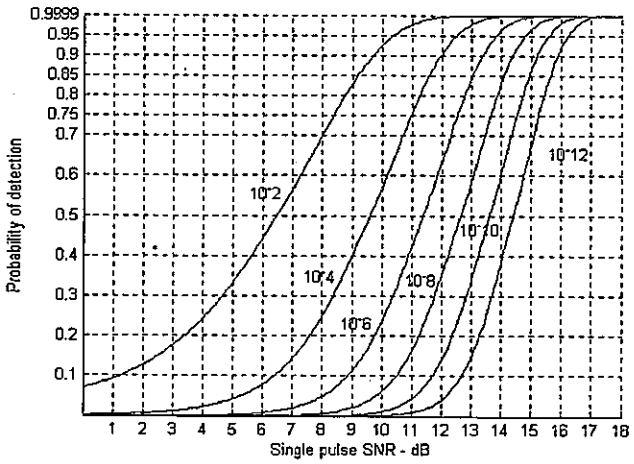


Figure Q3

(i) Compute the probability of false alarm P_{fa}.

[3 marks]

(ii) Determine the signal to noise ratio (SNR) at the detector's input.

[3 marks]

(iii) At what SNR would the probability of detection drop to 0.9 (with P_{fa} not changed)?

[3 marks]

(c) Consider a monostatic radar operated at 12 Hz. A scattered signal is received from four points on a complex target surface. The first point is 20 km away from the radar, while the other three points are 2 m, 3 m, and 5 m away from the first point on the same line of sight. Find the sum of received signal voltages at time ($t = 20$ second) from the four points, as a function of Σ and r_k. Assuming that all the received signals have identical amplitude $\sqrt{\sigma_o}$=0.2 and phase value of 20 degree. Analyze the received signal voltage in term of amplitude and phase.

[8 marks]

Continued...

Question 4

(a) A stable oscillator (STALO) is one of the important component in radar circuit design. Briefly explain THREE (3) specifications and THREE (3) types of STALO.

[6 marks]

(b) Figure Q4 shows the block diagram of an airborne synthetic aperture radar (SAR) system.

(i) Determine the main purpose of using a circulator in this design.

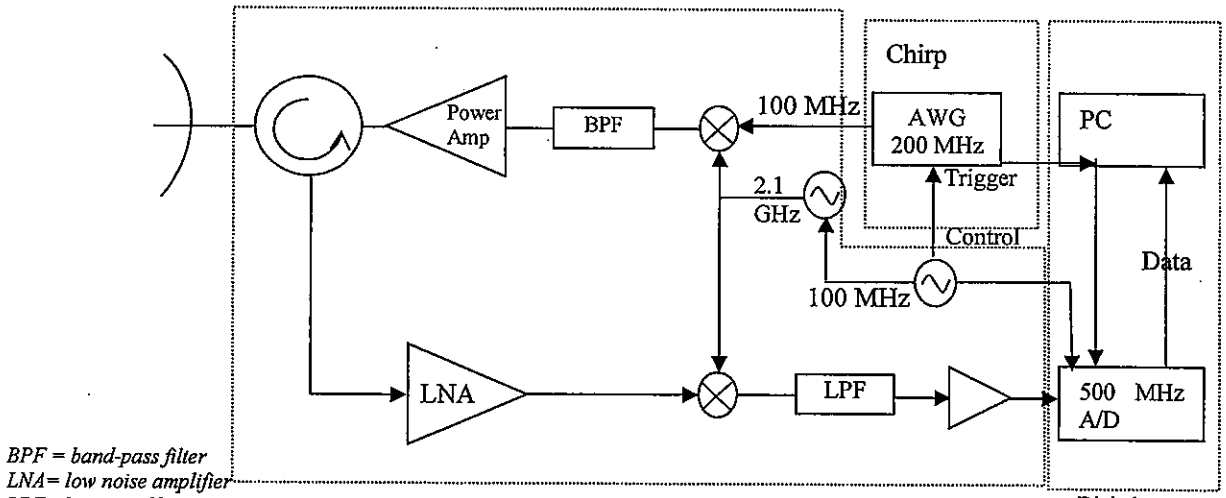
[3 marks]

(ii) Find out the main disadvantage of the circulator if we wish to transmit a high power signal. Modify and create the circuit to address this disadvantage and draw an appropriate figure to illustrate the design.

[6 marks]

(iii) Briefly explain the main function of low noise amplifier (LNA) in the receiver.

[3 marks]



BPF = band-pass filter
LNA= low noise amplifier
LPF= low pass filter
A/D = analog to digital

Figure Q4

Continued...

(c) Suggest a mode of operation for each of the following typical design cases in radar systems.

(i) case 1 - NASA/JPL Shuttle Radar Topographic Mission (SRTM)
System level objective: To generate high resolution 3D map of the land surface between ±60° of latitude representing about 80% of the overall Earth's surface

(ii) case 2 - MACRES-MMU Airborne SAR System
System level objectives: To develop an instrument that serves as a test-bed for SAR techniques and its related technologies.

[7 marks]

End of Paper